The Effect of *Pinnotheres hickmani* on the Meat Yield (Condition) of *Mytilus edulis* Measured Several Ways

BY

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(2 Text figures)

INTRODUCTION

Lowered meat content of bivalves caused by pinnotherid crabs has been reported by several authors, e.g., Haven (1958) for *Crassostrea virginica* by *Pinnotheres ostreum,* Kruczynski (1972) for *Argopecten irradians concentricus* by *Pinnotheres maculatus,* and Anderson (1975) for *Mytilus californianus* by *Fabia subquadrata.*

There are two possible causes of lowered meat yields. Damage to the gills, the mere presence of the crab on gills, or both. Or, the crab may be eating the potential food of the host. Observation of the feeding behaviour of *Pinnotheres pisum* (Orton, 1920) and *P. ostreum* (Stauber, 1945) showed that both obtain food by scraping the chelae over the host's gills and transferring the food-laden mucous strands to their mouths. The crabs did not eat pseudofaeces. Caine (1975) observed that *P. maculatus* scrapes the food from the gill with its fourth walking leg which is then wiped clean by the chela and the food is transferred to the mouth. It would appear that crabs do eat their hosts' food, although the food of mussels has not been precisely defined. Kruczynski (1975) showed that crabs consume the same food as the host by feeding radioactively labelled phytoplankton to bay scallops infested with *P. maculatus.* Gut analysis of the crabs revealed the tagged phytoplankton, which indicated that the crabs ate the scallops' food.

In an attempt to determine what effect *Pinnotheres hickmani* had on *Mytilus edulis* the condition indices of wild and cultured mussels were determined from several locations in Australia. The condition indices of those found to have crabs were compared to those without crabs. Only the data from Port Phillip Bay were useful. Subsequently an experiment was undertaken comparing the condition indices of non-infected mussels with those of mussels manually infected with *P. hickmani.*

Condition index is a term used to refer to the amount of soft tissue present in a bivalve. To be useful in comparing meat content of bivalves of different size, the amount of meat present is compared to the space bounded by the valves when fully closed, i.e., the internal volume. Condition index, expressed as a percentage, can be measured by comparing the weight of soft tissue to the internal volume of the bivalve.

$$\text{Condition Index} = \frac{\text{meat weight}}{\text{internal volume}} \times 100$$

Traditionally, condition index has been measured using oven dried meats (Medcof & Needler, 1941). Baird (1958) showed that use of meat volume, rather than weight was also valid.

METHODS

The condition index of 600 wild mussels from various localities throughout their distribution in Australia was determined using oven dried meats, meat volumes and meats dried with absorbent paper (henceforth referred to as wet meat to distinguish from oven dried meat). The internal volume was determined using the method of Andrews (1963). The various methods of determining condition were compared to determine the validity of using meat weights dried with absorbent paper since this was more expedient than using oven dried meats or meat volumes.

For the experiment 37 female and 23 male crabs were introduced into juvenile mussels from a culture raft in an area where mussels were known to have insignificant infestations of crabs and other harmful symbionts (Pregenzer, 1978). A blunt scalpel was used to force open the valves of the mussel just far enough to insert the crab without causing damage to either the crab or the mussel. It had pre-

viously been determined that neither the crab nor the mussel would be harmed by this procedure. Sixty mussels of approximately the same size were selected as a control. Both control and experimental mussels were numbered and placed in cubic cages 0.3 m on an edge and enclosed with 1.5 cm mesh wire. The cages were suspended 0.6 m apart under the raft from which the mussels were taken. The cages were cleaned of epiphytic organisms once a month so that water flow to the mussels inside would not be hindered.

The experiment was terminated after a period of infestation of $4\frac{1}{2}$ months, and just before the mussels were expected to reach peak condition. Condition indices were determined for each mussel following the procedures modified from Medcof & Needler (1941), Baird (1958) and Andrews (1963).

RESULTS

The correlation between condition indices measured by wet meat weights and meat volumes was highly significant ($r = 0.99$, Figure 1). The correlation coefficient between wet and dry meat weights was not as high ($r = 0.76$) but it was acceptable at the 99.9% level (Figure 2). Every tenth value is plotted in Figures 1 and 2.

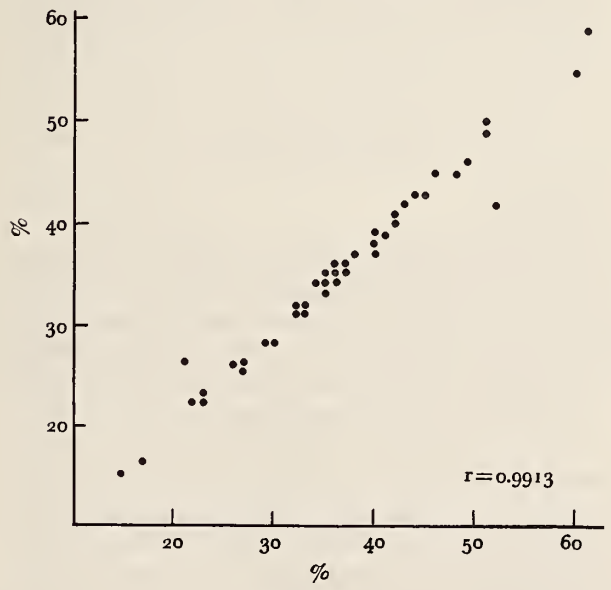

Figure 1

A linear regression of condition indices measured by meat volume (Y axis) and by wet meat weight (X axis)

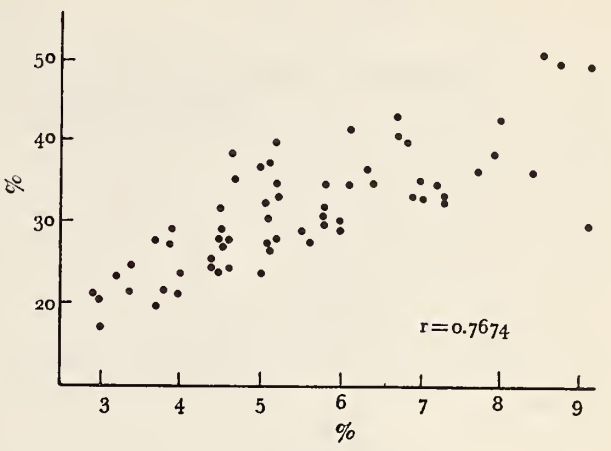

Figure 2

A linear regression of condition indices measured by meat volume (Y axis) and by dry meat weight (X axis)

On only two occasions were the condition indices of uninfested wild mussels greater than those housing crabs, i.e., 7 XI 1974 and 12 XII 1974 (Table 1).

At the termination of the experiment no male crabs and only 20 female crabs were recovered from the experimental mussels. One female was recovered from the control group. Five of the experimental mussels and 16 control mussels were lost due to natural mortality, the cleaning procedure and unknown causes (perhaps storms or curious people).

There was no significant difference in growth (length increase) or shell weight between the control and experimental groups. There was a significant difference between the condition indices of the experimental and control groups, when calculated with either wet or dry meat weights (Table 1). Experimental mussels which lost their crabs during the experiment showed a significant difference, when compared to control, and to experimental mussels which retained their crabs, in both wet and dry weight condition indices. The condition of these mussels was greater than those which retained their crabs and less than the control mussels (Table 2).

Table 1

A comparison of condition indices and meat weights of mussels experimentally infected with crabs, those mussels whose crabs left and control groups.

	Wet meat determinations			Dried meat determinations		
	With crabs	Control	Crabs left host	With crabs	Control	Crabs left host
Condition index g/cc × 100						
X	28.9	37.1	33.2	4.1	6.4	5.1
S	6.2	8.5	5.8	1.6	2.6	1.4
N	19	43	36	19	41	36
	t = 3.72		t = 3.20	t = 3.50		t = 2.66
	Rej. H_0, P > 0.001		Rej. H_0, P > 0.05	Rej. H_0, P > 0.01		Rej. H_0, P = 0.01
Meat weights g						
X	3.78	5.11	4.14	0.55	0.90	0.64
S	0.94	1.30	1.10	0.26	0.43	0.22
N	19	43	36	19	43	36
	t = 3.96		t = 3.44	t = 3.26		t = 3.29
	Rej. H_0, P > 0.001		Rej. H_0, P > 0.002	Rej. H_0, P = 0.002		

X designates mean, S the standard deviation, and N the number of values.

Table 2

Mean condition indices for mussels with (w) and without (w/o) crabs from Port Phillip Bay, Australia. X indicates the mean C.I., S the standard deviation, and N the number of mussels.

	w/o	w	w/o	w
	24-4-74		26-6-74	
X	32.75	31.69	36.42	34.05
S	5.68	6.81	6.88	8.94
N	18	27	18	22
	t = 0.53		t = 0.95	
	11-7-74		29-8-74	
X	36.70	31.25	22.47	20.36
S	7.14	6.30	8.21	5.01
N	10	39	32	16
	t = 2.32		t = 0.92	
	Reject H_0 at P = 0.05			
	12-12-74			
X	51.13	44.31		
S	3.28	6.00		
N	12	13		
	t = 3.29			
	Reject H_0 at P = 0.01			

Wet meat weights of mussels which retained the crabs were 26% lower and dried meat weights 39% lower than the wet and dry meat weights of control mussels, respectively.

DISCUSSION

Techniques

The high correlation between condition measured by wet meat weights and condition measured by meat volumes is not surprising. Since the density of mussel meat and water are so similar, the meats weigh very little in water. Andrews (1963) noted that the specific gravity of oyster meats was similar to that of salt water.

The lower correlation coefficient between wet and dry meat is probably due to variable amounts of water contained in the mussel meats. However, the high level of probability(99.9%) of the correlation between the 2 methods suggests that the variability of water content is not a sufficiently strong argument to prevent the valid use of wet meat weights to determine condition. Wet meat weights and dry meat weights were used by Dethlefsen (1974) to determine condition indices but he did not comment on the comparison of the two techniques.

Effect on Condition

The information from Port Phillip Bay mussels gives a more reliable indication of the effect of the crab than does other field work. Both the crabs and the mussels were all first-year class, since they were taken from a raft which was in the water less than one year, and the number of infested and non-infested mussels was approximately equal. During most of the year the mussels were infested with small and immature crabs. The highly significant difference in condition and meat weights between infested and non-infested mussels in December (Table 2) suggests two things: (i) the effect of the crab is only noticeable when condition is high; (ii) condition is reduced only by larger crabs.

The condition index of the control mussels from the experiment was less than the condition index of the mussels sampled from Port Phillip Bay in December, 1974, but was still very significantly different from that of the experimental group. This indicates that although the mussels were not up to full condition, the adult crabs significantly lowered condition. The presence of larger crabs for only a short period of time also lower condition (Table 1).

The greater reduction of dry meat weights compared to the reduction of wet meat weights suggests that the crabs' presence produces a lower quality of meat since a higher water content is indicated in infested mussels. ANDERSON (1975) reported a lower glycogen level in *Mytilus californianus* infested with *Fabia subquadrata*. Perhaps the higher water content of infected mussels reflects a lower glycogen content.

The significance of finding a female crab in a control mussel is not certain. It is unlikely that the mussel was invaded from wild crab stocks due to the extremely low abundance of *Pinnotheres hickmani* in that area. It is also unlikely the crab could have invaded a control mussel after leaving an experimental mussel since large female crabs are virtually non-swimmers.

CONCLUSION

It is equally valid to measure condition using dried meat weights, wet meat weights or meat volumes.

Mature female *Pinnotheres hickmani* can significantly reduce condition and meat yields of mussels by as much as 26%, possibly because of consumption of a significant quantity of food which the mussel has filtered. Both male and female crabs decrease the pumping rates of *Mytilus edulis* (PREGENZER, 1979) and this must contribute to the lowered meat yields. Which of these two factors plays the greater role in reduced condition is not important. Reduced condition caused by crabs is a possible cause of lost revenue to the mussel farmer.

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